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A new species of *Nesotanais* Shiino, 1968 (Crustacea, Tanaidacea) from Japan, with a key to species and a note on male chelipeds

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Abstract

The new species *Nesotanais ryukyuensis* **sp. n.** is described from Japan. *Nesotanais ryukyuensis* most closely resembles *N. rugula* Bamber, Bird & Angsupanich, 2003, but can be distinguished by the length of simple seta on maxillipedal basis and the shape of cheliped in male. A key to species of the genus *Nesotanais* is given. The male chelipeds of *N. rugula* are redescribed. The serial ridges on the inner surface of the chelipedal propodus and dactylus in *Nesotanais ryukyuensis* and *N. rugula* are likely to be stridulating ridges that might produce sound.

Keywords

Nesotanais, Tanaidacea, brackish water, Japan, key, sounding organ

Introduction

At present, more than 200 genera are recognized as valid in the order Tanaidacea (Anderson 2009). Most tanaidaceans live in marine environments, though a small number of species has been reported from non-marine habitats; the latter are classified into 10

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genera (Muus 1967; Shiino 1968; Boesch 1973; Băcescu and Guțu 1974; Geldiay et al. 1977; Sieg and Heard 1983; Angsupanich 2001; Jaume and Boxshall 2008). The genus *Nesotanais* is one of these genera, including three species: *N. lacustris* Shiino, 1968 from Lake Tegano, Rennell Island, Solomon Islands; *N. maclaughlinae* Guțu & Iliffe, 1989 from the Tide Rope Cave, Eil Malk Island, Palau; and *N. rugula* Bamber, Bird & Angsupanich, 2003 from Songkhla Lake, Thailand. Males in this genus commonly possess bizarre chelipeds, i.e., the chela (propodus and dactylus) is twisted at right angles with the dactylus situated inwards, and bears a "flange" or proximal extension of the outer proximal part of the propodus (Bamber et al. 2003).

Our sampling in a brackish river in Okinawa Island, southwestern Japan, in 2008, yielded one undescribed species belonging to *Nesotanais*. This paper describes and illustrates the species, and presents a key to the species of the genus.

The interesting feature found in this undescribed species was that the male had serial ridges on the inner surface of the cheliped propodus and dactylus. Among congeners, *Nesotanais rugula* has been reported to have such ridges on the cheliped dactylus. This prompted us to examine the type material of *N. rugula* to compare the cheliped between these two species. During the course of our observation, it turned out that the chelipeds in the male allotype of *N. rugula* show some features different from the original description. A redescription of the male cheliped in *N. rugula* is thus presented in this paper.

In addition to *Nesotanais rugula*, serial ridges on the cheliped were reported in the species of the genus *Imitapseudes* (a junior synonym of *Apseudomorpha*) by Menzies (1953), who as well as Bamber et al. (2003), implied a stridulating device as the possible function for these ridges. At the same time Menzies (1953) and Bamber et al. (2003) also suggested that these structures might be a coupling or locking device. Our observation on the behavior of the present new species suggests that the ridges are a stridulating apparatus, rather than a coupling or locking device. The structure and function of this stridulating apparatus is discussed.

Materal and methods

Specimens were collected at Noha River (Figs 1–3), a brackish river in Okinawa Island, Japan, on 29 February, 23 May, and 29 July 2008. Tanaidaceans were collected by a plankton net with 0.1 mm-mesh opening from muddy bottom sediment in shallow water. Specimens were fixed and preserved in 99% ethanol.

Dissections were carried out with chemically sharpened tungsten wire needles under a dissection microscope. Appendages were mounted on glass slides in glycerin and were sealed by nail polish. Digital drawings were based on draft line drawings produced by using a camera lucida, and/or digital images taken by a digital camera system. Terminology follows Larsen (2003).

The type material is deposited in the Zoological Institute, Faculty of Science, Hokkaido University, Japan (ZIHU).

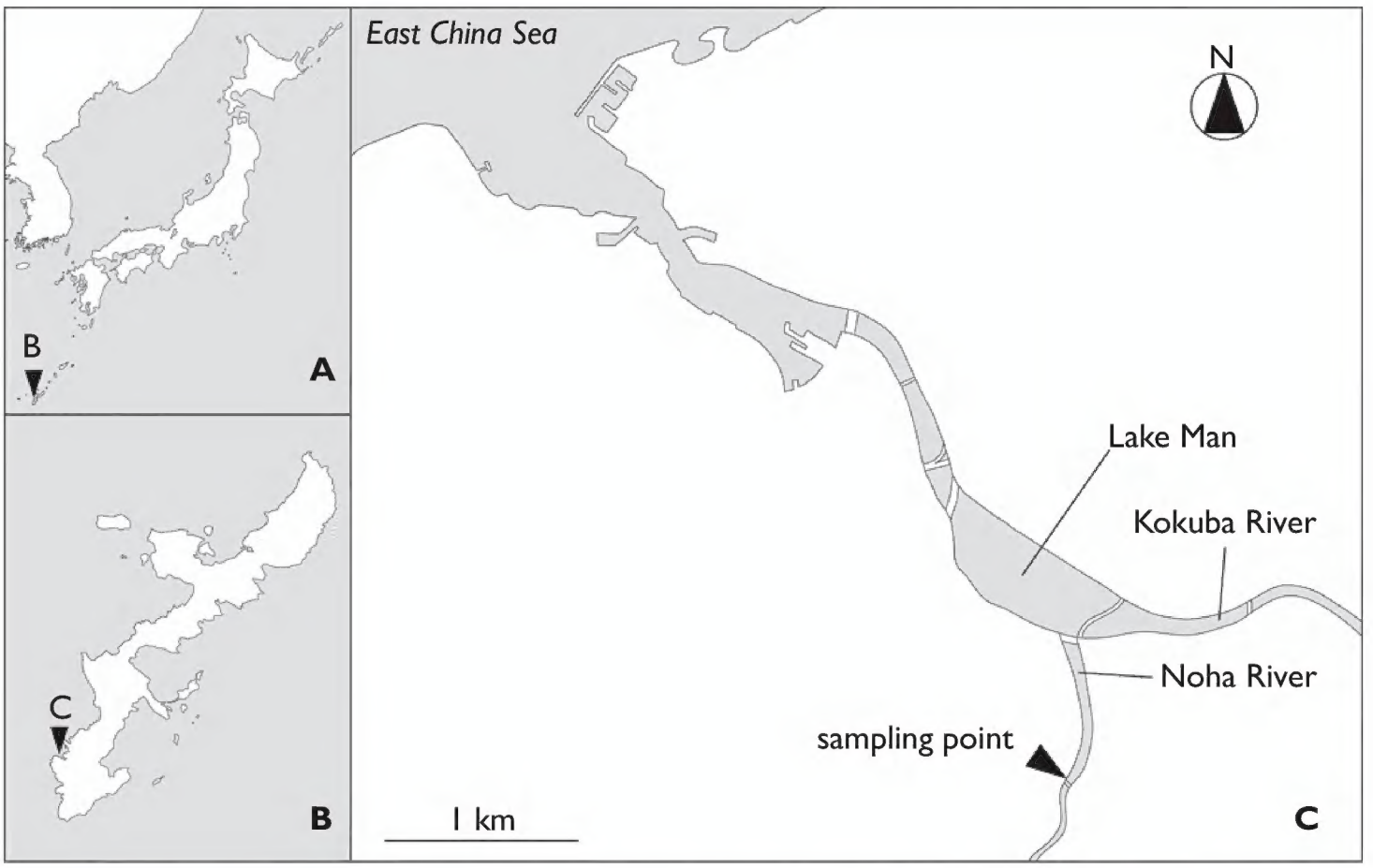

Figure 1. Maps showing the sampling point. **A** location of Okinawa in Japan **B** location of sampling area in Okinawa Island **C** location of the sampling point within Noha River.

Systematics

Order Tanaidacea Dana, 1849
Suborder Tanaidomorpha Sieg, 1980
Superfamily Paratanaoidea Lang, 1949
Family Nototanaidae Sieg, 1976

Genus *Nesotanais* Shiino, 1968
Type species: *Nesotanais lacustris* Shiino, 1968

***Nesotanais ryukyuensis* sp. n.**
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Figs 4–8

Material examined. Holotype, male (ZIHU-3822), 26°11'13.38"N, 127°41'8.84"E, Noha River (near Ishihiyabashi bridge), Naha, Okinawa, Japan, muddy bottom sediment, 50 cm depth, salinity 0‰, 29 February 2008 (dissected). Allotype, ovigerous female (ZIHU-3823), same data as holotype (dissected). Paratypes: non-ovigerous female (ZIHU-3824), same data as holotype (dissected); ovigerous female (ZIHU-3825), same data as holotype; ovigerous female (ZIHU-3826), almost the same locality as holotype, salinity not recorded, 23 May 2008; non-ovigerous female (ZIHU-

Figure 2. Photograph of the sampling point, Noha River, taken from Ishihiyabashi Bridge spanning the river.

3827), almost the same locality as holotype, salinity 20‰, 29 July 2008. All specimens were collected by Keiichi Kakui.

Accompanying fauna. *Longiflagrum nasutus* (Nunomura, 2005) and *Sinelobus* sp. (Tanaidacea); *Victoriopisa ryukyuensis* Morino, 1991 and *Corophium* sp. (Amphipoda).

Diagnosis (male). *Nesotanais* with maxillipedal basis with one pair of simple setae, the latter being apparently longer than maxillipedal palp. Maxillipedal palp without any spiniform setae. Carpus of cheliped without any outer ridges. Dactylus of cheliped with one small and two toothed processes on cutting surface. Cheliped flange short, distally rounded. Plumose setae of pleopod rami on both distal and outer margins. One "step-tipped plumose seta" on inner margin of pleopod endopod.

Etymology. The specific epithet, noun in apposition, is after "Ryukyu", the old name of the type locality, Okinawa.

Description of male (holotype, ZIHU-3822). *Body* (Fig. 4A, 4B). Cylindrical, but slightly flattened dorsoventrally; 1.97 mm in length, about 4.9 times as long as wide, white in ethanol, without any pigmentation.

Cephalothorax about 0.25 of total body length, with one pair of lateral simple setae near eyes. Eyes well defined, black. Anterior edge obtuse triangular in shape from dorsal view. Posterior end laterally swollen, with large sclerite where cheliped is attached.

Figure 3. Photograph of the close view of the sampling point. Bottom sediment was taken from underwater.

Pereon. Each pereonite with pair of lateral simple setae; pereonite 1 with one pair of dorsolateral simple setae. All pereonites laterally rectangular; pereonite 1 shortest, pereonites 2 and 3 shorter than succeeding; pereonites 4–6 subequal in length.

Pleon about 0.26 times total body length, with five pleonites and pleotelson, as wide as pereon. Pleonites all wider than long, with one pair of lateral simple setae. Pleotelson wider than long, gradually tapering posteriorly from uropodal insertion; with one pair of lateral, one pair of dorsal, and two pairs of posterior setae.

Antennule (Fig. 5A, 5a1) four-articled, about 0.9 times as long as cephalothorax. Article 1 about 0.55 times as long as cephalothorax, with two medial and two distal simple setae, several broom setae, and five proximal "feeble branching setae" (Fig. 5a1). Article 2 0.6 times length of article 1, with one simple seta and two broom setae. Article 3 shortest, naked. Article 4 with six simple setae and three aesthetascs at tip.

Antenna (Fig. 5B) six-articled, narrow, about 0.85 times as long as antennule. Article 1 naked. Article 2 long, 2.3 times as long as article 3, with one distal simple seta. Article 3 with one distal simple seta. Article 4 longest, with one distal simple seta, one medial and five distal broom setae. Article 5 with one distal simple seta. Article 6 with six simple setae.

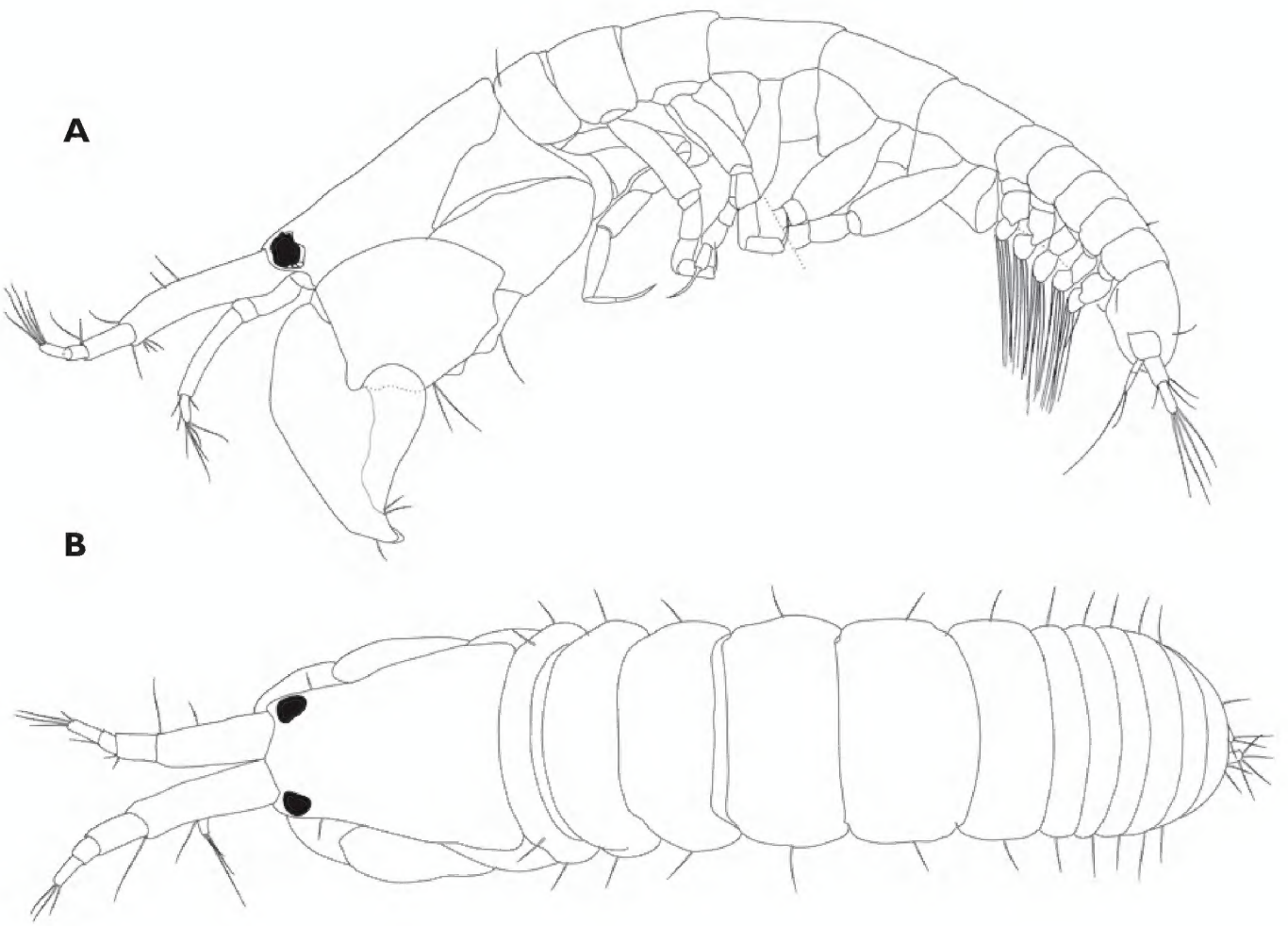

Figure 4. *Nesotanais ryukyuensis* sp. n. **A, B** holotype, male (ZIHU-3822) **C, D** allotype, ovigerous female (ZIHU-3823). **A** body, lateral view **B** body, dorsal view **C** body, lateral view **D** body, dorsal view. Scale bar equals 0.5 mm.

Mouthparts reduced. *Maxilliped* (Fig. 5C) bases completely fused, proximally widened, pear-shaped, each with one ventrodistal simple seta apparently longer than length of palp. Endites reduced. Articulation between palp articles 1–2 obscure; palp article 4 small; all palp articles naked. *Epignath* (Fig. 5C) falciform, tip broken.

Cheliped (Fig. 6A–C) basis with broad articulation with cephalothorax via sclerite, as long as wide, with no free posterior portion, and one outer simple seta. Merus triangular, with one ventral simple seta and one ventrodistal process. Carpus hexagonal, 1.27 times as long as wide, with two ventral setae, one ventroinner and one ventral processes. Chela as long as carpus, twisted about 90-degrees with dactylus situated inwards. Propodal palm with seven short and one long inner simple setae at dactylus insertion, and longitudinal parallel series of cuticular ridges in inner region. Fixed finger with one dorsoproximal, three dorsosubdistal, and two ventrosubdistal simple setae, and several inner small teeth and one inner subdistal toothed process; curving ventrally at a position just distal to the ventrosubdistal setae. Flange short, 0.67 times as long as wide, with round end, bearing inner crenulations. Dactylus slightly longer than fixed finger, gradually curving ventrally, with one ventromedial simple seta; three spiniform setae, one small and two toothed processes on cutting surface, and longitudinal parallel series of cuticular ridges in inner region.

Pereopod 1 (Fig. 5D, 5d1) about 0.7 mm long, longest among pereopods. Coxa with one long simple seta. Basis 0.34 times as long as total pereopod length, narrow (6.6 times as long as wide), cylindrical, and slightly arched; with slight dorsoproximal projection, bearing one simple seta. Ischium wider than long, with one ventral seta. Merus with one ventrodistal seta. Carpus longer than merus, with one dorsodistal, one inner distal, and one ventrodistal simple setae. Propodus longer than carpus, distally setulated (Fig. 5d1), with one ventrodistal simple seta and dorsodistal serration. Dactylus and unguis as long as propodus, falciform. Dactylus with one medial seta. Unguis 1.5 times as long as dactylus.

Pereopod 2 (Fig. 5E) 0.7 times as long as pereopod 1. Coxa like that of pereopod 1. Basis 0.4 times as long as total length, cylindrical, slightly curved; with slight dorsoproximal projection, bearing two broom setae. Ischium like that of pereopod 1. Merus with one ventrodistal simple and one spiniform setae. Carpus longer than merus, with one dorsodistal seta and two ventrodistal spiniform setae. Propodus as long as carpus, distally setulated, with one ventrodistal spiniform seta and dorsodistal serration. Dactylus and unguis slightly shorter than propodus, falciform. Dactylus naked; unguis as long as dactylus.

Pereopod 3 (Fig. 5F) shorter than pereopod 2. Otherwise like pereopod 2, except basis with one dorsoproximal broom seta.

Pereopod 4 (Fig. 5G) shorter than pereopod 3, without separate coxa. Basis 0.38 times as long as total length, inflated (1.95 times as long as wide) with two dorsoproximal and two (one lost in dissection) ventrodistal broom setae. Ischium like that of pereopod 3. Merus with two ventrodistal spiniform setae. Carpus as long as merus, with one dorsodistal simple seta, and two dorsodistal and two ventrodistal spiniform setae. Propodus longer than carpus, with one long spiniform and two ventrodistal

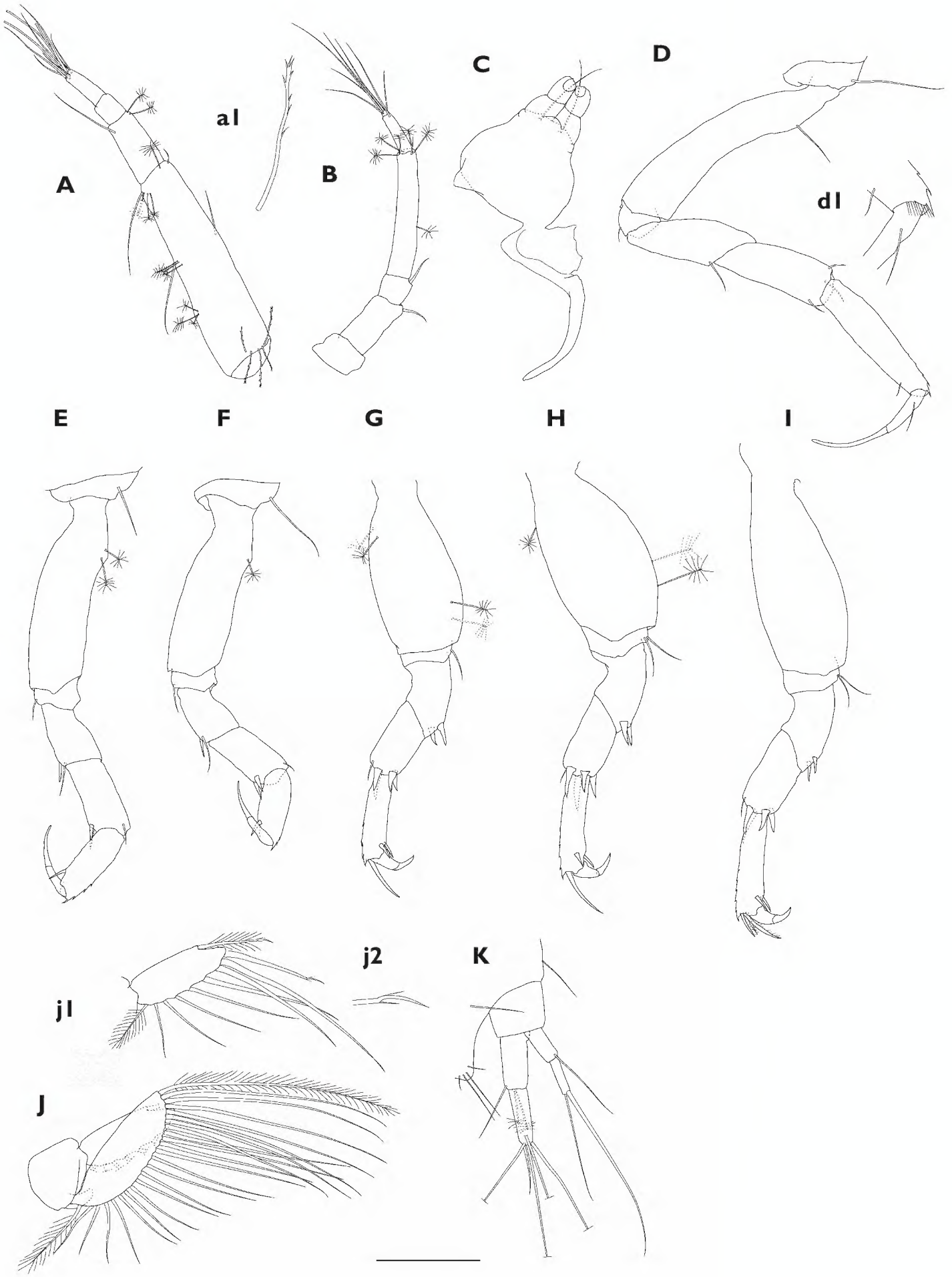

Figure 5. *Nesotanais ryukyuensis* sp. n. Holotype, male (ZIHU-3822). **A** right antennule **a1** feeble branching seta **B** right antenna **C** maxillipeds and right epignath **D** right pereopod 1 **d1** same, distal setulation of propodus **E** right pereopod 2 **F** right pereopod 3 **G** right pereopod 4 **H** right pereopod 5 **I** right pereopod 6 **J** right pleopod 1, most ornaments of setae not shown **j1** same, endopod, most ornaments of setae not shown **j2** same, distal part of step-tipped plumose seta **K** right uropod. Scale bar equals 0.1 mm.

spiniform setae, and dorsodistal serration. Dactylus and unguis shorter than propodus, claw-shaped. Dactylus naked. Unguis slightly shorter than dactylus.

Pereopod 5 (Fig. 5H) longer than pereopod 4, without separate coxa. Otherwise like pereopod 4, except basis with one dorsoproximal broom seta, and ischium with two ventrodistal simple setae.

Pereopod 6 (Fig. 5I) longer than pereopod 5, without separate coxa. Otherwise like pereopod 5, except basis naked, and propodus with three dorsodistal pinnate setae.

Pleopods (Fig. 5J, 5j1, 5j2) biramous, in five pairs, all similar. Basal article naked. Exopod uniarticulate, with 23 or 24 outer plumose setae. Endopod uniarticulate, with seven or eight outer plumose setae, and one inner and one distal "step-tipped plumose setae" (Fig. 5j2).

Uropod (Fig. 5K) basal article naked. Exopod biarticulate. Article 1 with one distal simple seta. Article 2 with two simple setae at tip. Endopod biarticulate, 1.5 times as long as exopod. Article 1 with one distal simple and two distal broom setae. Article 2 with five simple setae at tip.

Description of ovigerous female (allotype, ZIHU-3823; partially based on paratype, non-ovigerous female, ZIHU-3824): *Body* (Fig. 4C, 4D). Somewhat narrower than in male, 2.02 mm (1.70 mm in ZIHU-3824) in length, about 5.9 times as long as wide.

Cephalothorax similar to that of male, except posterior end not as swollen and anterior not as narrow behind the eyes.

Pereon and *Pleon* similar to those of male.

Antennule (Fig. 7A) three-articulated, about 0.7 times as long as cephalothorax. Article 1 about 0.45 times as long as cephalothorax, with two medial and two distal simple setae, several broom setae, and three proximal feeble branching setae. Article 2 one quarter length of article 1, with two simple setae and one broom seta. Article 3 as long as article 2, with six simple setae and one aesthetasc at tip.

Antenna (Fig. 7B) about 0.8 times as long as antennule; setation of articles 1–6 like those of male.

Mouthparts. Labrum (Fig. 7C) rounded, naked. *Mandibles* (Fig. 7D, 7E) molar process well developed, bearing distal row of denticles. Body with bumpy outer margin. Left mandible (Fig. 7D) incisor with several distal denticles; *lacinia mobilis* well developed, with seven teeth. Right mandible (Fig. 7E) crenulate at subdistal margin, incisor apex bifid. *Labium* (ZIHU-3824; Fig. 7F) inner lobe tapering distally, naked. Outer lobe rounded, naked. *Maxillule* (Fig. 7G, 7g1) endite with nine distal spiniform setae and outer subdistal row of simple setae. Palp articulation obscure, with two setae. *Maxilla* lost during dissection. *Maxilliped* (Fig. 7H) bases completely fused, triangular, widest anteriorly, with one pair of distal simple setae over-reaching endites. Endites partly fused, triangular, widest anteriorly, each with one ventrodistal simple seta and two distal tubercles. Palp article1 parallelogram in shape, naked; article2 with one distal and two ventrodistal simple setae; article 3 with inner extension, bearing one inner simple and three inner ventral setulate setae; article 4 with two simple, two pinnate, and two setulate setae. *Epignath* (Fig. 7I) falciform, setulate at tip.

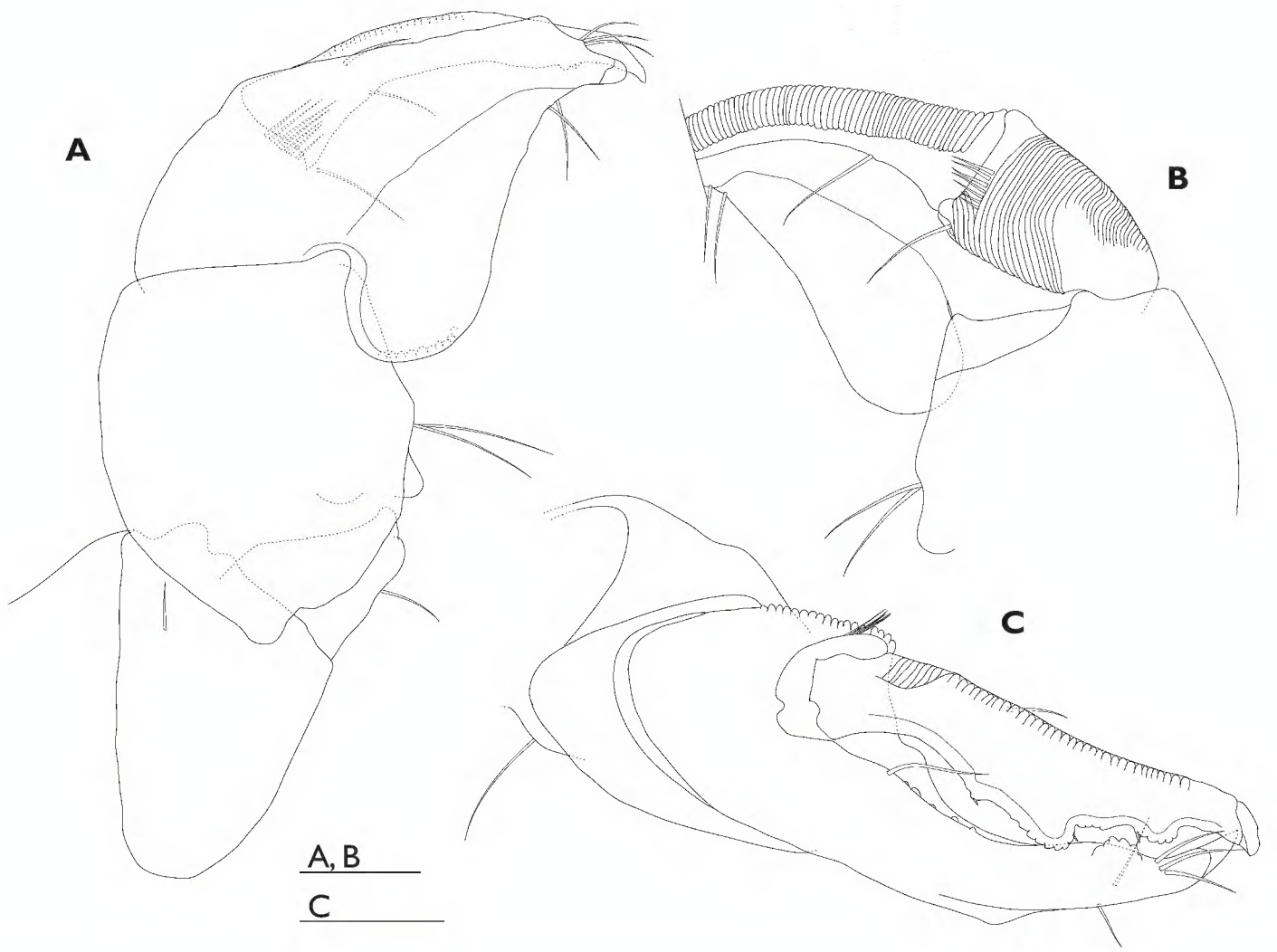

Figure 6. *Nesotanais ryukyuensis* sp. n. Holotype, male (ZIHU-3822). **A** right cheliped, outer view **B** same, inner view of chela **C** same, anterodorsal view of chela. Scale bars equal 0.1 mm.

Cheliped (Fig. 7J, 7j1) basis with broad articulation with cephalothorax via sclerite, slightly longer than wide, with no posterior free portion, and one outer simple seta. Merus triangular, with one ventral simple seta. Carpus gradually widening distally, about 1.35 times as long as wide, with one short dorsodistal and two ventral simple setae. Chela as long as carpus, in general orientation. Propodal palm with seven short and one long inner, and one outer simple setae at dactylus insertion. Fixed finger with two ventral and three dorsal simple setae, one distal bifurcate process, and one distal lamella. Dactylus slightly longer than fixed finger, with one inner proximal simple seta and three small teeth on cutting surface.

Pereopods 1–6 (Fig. 8A–G) somewhat thicker and shorter than in male, setation like those of male.

Pleopods (Fig. 8H, 8h1) biramous, in five pairs, all of them similar and like those of male.

Uropod (Fig. 8I) similar to that of male, except endopod article 2 with three simple and two broom setae at tip.

Habitat. Specimens of *Nesotanais ryukyuensis* were collected from muddy sediment together with the parapseudid *Longiflagrum nasutus* (Nunomura, 2005) and tanaid *Sinelobus* sp. The sediment consisted of upper soft and bottom stiff layers. All three tanaidacean species occurred in the upper soft layer.

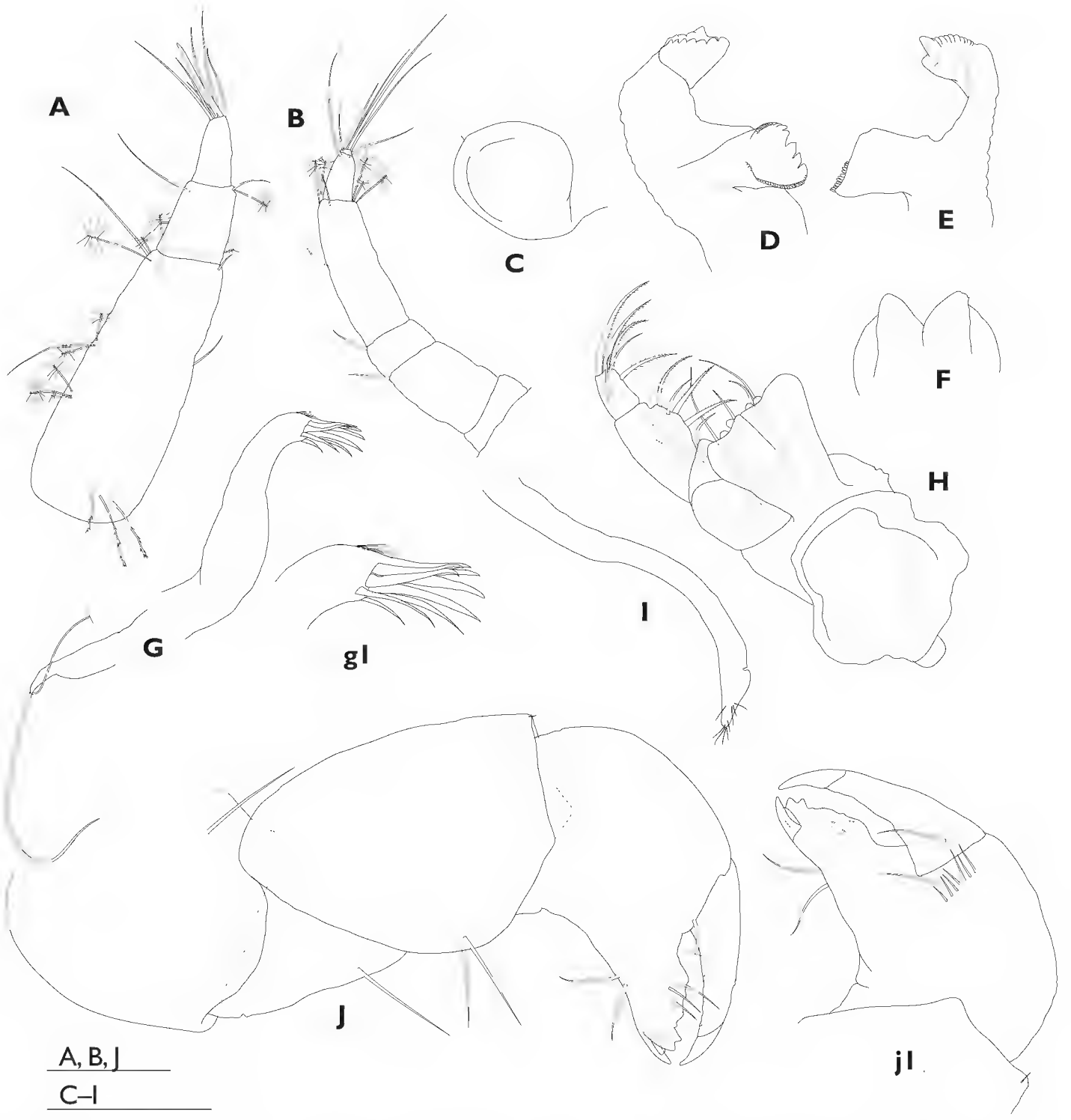

Figure 7. *Nesotanais ryukyuensis* sp. n. **A–E, G–J** allotype, ovigerous female (ZIHU-3823) **F** paratype, non-ovigerous female (ZIHU-3824). **A** right antennule **B** left antenna **C** labrum **D** left mandible **E** right mandible **F** labium **G** left maxillule **gI** same, endite **H** maxillipeds, right palp not shown **I** epignath **J** right cheliped, outer view **jI** same, inner view of chela. Scale bars equal 0.1 mm.

Nesotanais rugula Bamber, Bird & Angsupanich, 2003

Fig. 9A–D

Suplemented description of male chelipeds (allotype, NHM 2001.6687). Basis with broad articulation with cephalothorax via sclerite, as long as wide, with one outer simple seta. Merus subtriangular, with one ventral simple seta and one ventrodistal small process. Carpus hexagonal, 1.16 times as long as wide, with one short dorsodistal and two ventral simple setae, one ventroinner and one ventral processes, and longitudinal

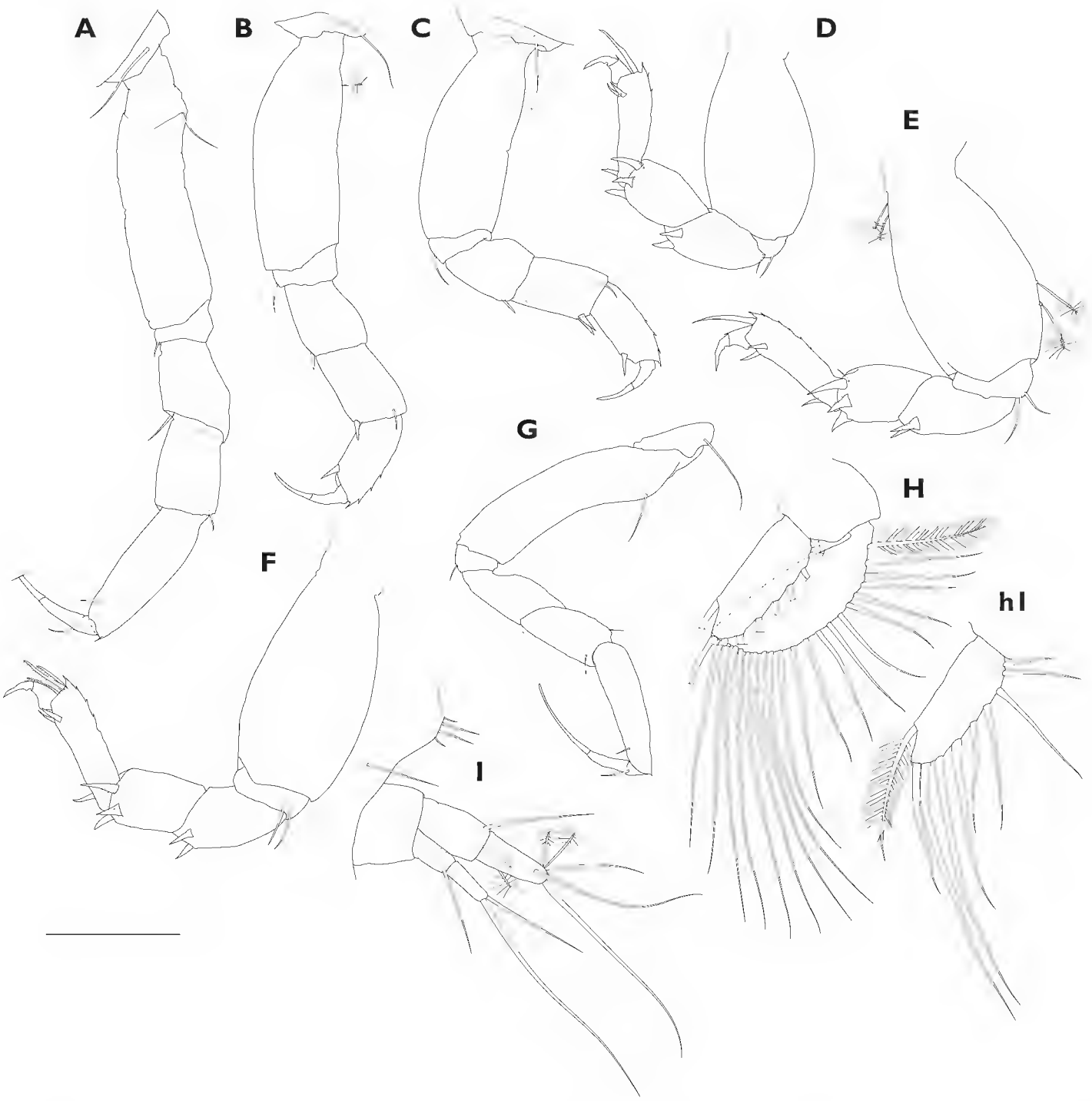

Figure 8. *Nesotanais ryukyuensis* sp. n. **A–F, H, I** allotype, ovigerous female (ZIHU-3823) **G** paratype, non-ovigerous female (ZIHU-3824). **A** right pereopod 1 **B** right pereopod 2 **C** right pereopod 3 **D** right pereopod 4 **E** right pereopod 5 **F** right pereopod 6 **G** right pereopod 1 **H** right pleopod 1, most ornaments of setae not shown **hI** same, endopod, most ornaments of setae not shown **I** left uropod. Scale bar equals 0.1 mm.

parallel series of cuticular ridges in outer region (Fig. 9A). Chela longer than carpus, twisted about 90-degrees with dactylus situated inwards. Propodal palm with nine short and one long inner simple setae at dactylus insertion, and longitudinal parallel series of cuticular ridges in inner region (Fig. 9B). Fixed finger with one dorsoproximal, three dorsosubdistal, and two ventrosubdistal simple setae, and one inner subdistal process (Fig. 9C) curving ventrally at a position just proximal to the ventrosubdistal setae; tip rounded, not bifid (right cheliped was broken, lacking its tip distal to the three dorsosubdistal setae). Flange long, 1.09 times as long as wide, with rectangular end, bearing inner crenulations. Dactylus slightly longer than fixed finger, gradually curving ventrally, with one ventromedial simple seta; three spiniform setae, and one

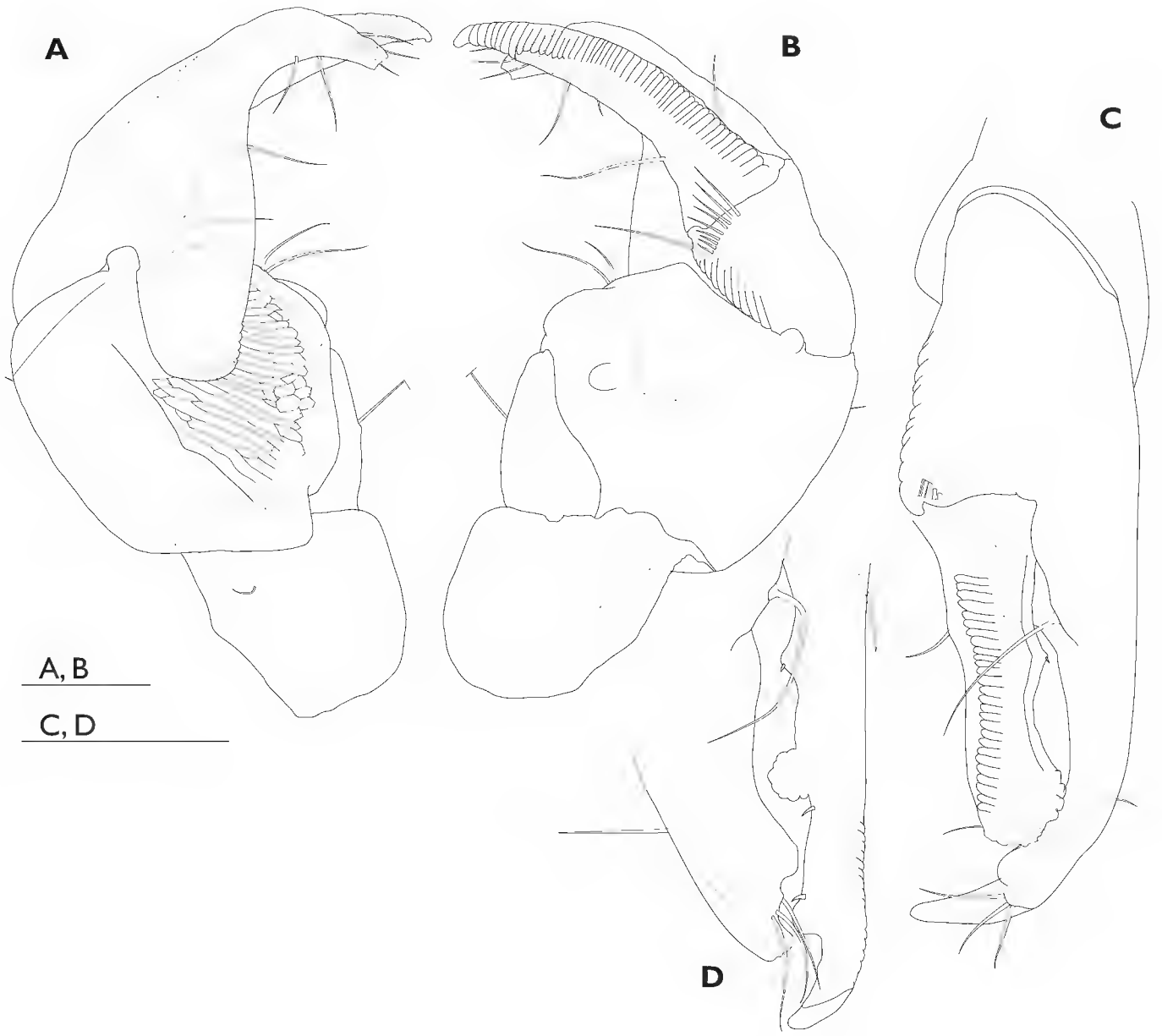

Figure 9. *Nesotanais rugula* Bamber, Bird & Angsupanich, 2003. Allotype, male (NHM 2001.6687). **A** right cheliped, outer view **B** same, inner view **C** left cheliped, anterodorsal view of chela **D** right cheliped, anterodorsal view (slightly different angle from C). Scale bars equal 0.1 mm.

small proximal triangular, one medial toothed, and one small subdistal rounded processes on cutting surface (Fig. 9D), and longitudinal parallel series of cuticular ridges in inner region (left cheliped was broken, lacking its tip distal to the toothed process).

Remarks. The original description of the male cheliped of *Nesotanais rugula* was based on the right cheliped. However, our observation revealed that both chelipeds of this species were apparently broken at different places, i.e., the left one lacks the tip of the dactylus, and the other lacks the tip of the fixed finger. Therefore, the original description is supplemented with respect to the following characters. The distal shape of the fixed finger being rounded (bifid according to Bamber et al. 2003), the number and shape of the processes on the dactylus being one small proximal triangular, one medial toothed, and one small subdistal rounded processes (one rounded op. cit.). Although the serial ridges on the inner surface of the propodal palm were illustrated by Bamber et al. (2003: fig. 20C), no statement on this structure was given in the original description.

Discussion

Nesotanais ryukyuensis sp. n. is the fourth known species of the genus. *N. ryukyuensis* most closely resembles *N. rugula*, but can be distinguished by the following male characters: 1) the length of ventrodistal simple seta on the maxillipedal basis (apparently longer than maxillipedal palp in *N. ryukyuensis* versus shorter than the palp in *N. rugula*), 2) outer cuticular ridges on chelipedal carpus (absent in *N. ryukyuensis* versus present in *N. rugula*), and 3) the shape of the chelipedal flange (short and rounded in *N. ryukyuensis* versus long and rectangular in *N. rugula*). In addition, the females of both species can be separated by the following characters: 1) the length of antenna article 2 (more than twice as long as article 3 in *N. ryukyuensis* versus slightly longer than article 3 in *N. rugula*), and 2) chelipedal carpus (that of *N. ryukyuensis* broader than that of *N. rugula*).

The new species differs from *Nesotanais lacustris* in 1) the number and the shape of processes on the dactylus of the male cheliped (one small and two toothed in *N. ryukyuensis* versus two triangular in *N. lacustris*), 2) the shape of the edge of the flange (rounded in *N. ryukyuensis* versus rectangular in *N. lacustris*) in the male cheliped, 3) the length of ventrodistal simple seta on the maxillipedal basis of the male (apparently longer than the maxillipedal palp in *N. ryukyuensis* versus apparently shorter than the palp in *N. lacustris* according to Shiino (1968) or as long as the palp according to Sieg (1978)), and 4) the number of processes on the chelipedal fixed finger of the female (two in *N. ryukyuensis* versus more than four in *N. lacustris*).

Nesotanais ryukyuensis also differs from *N. maclaughlinae* in 1) the setation of the pleopodal rami (present on distal and outer margins in *N. ryukyuensis* versus absent on outer margin in *N. maclaughlinae*), and 2) the spiniform seta ("spine" in Guţu and Iliffe (1989)) on the tip of the maxillipedal palp (absent in *N. ryukyuensis* versus present in *N. maclaughlinae*).

Nesotanais ryukyuensis and *N. rugula* bear serial ridges on the inner surface of the propodus and dactylus on both chelipeds. Menzies (1953), Bamber et al. (2003) and Larsen (2005) speculated about two different functions for such chelipedal ridges, namely "locking mechanism" or "sound production" hypotheses. While Menzies (1953) and Bamber et al. (2003) considered the "locking mechanism" was more probable, Larsen (2005) suggested that the ridges would be used for sound production. As to the inner ridges of *N. ryukyuensis* and *N. rugula*, we concur with Larsen (2005), based on 1) the position of the ridges, 2) the mobility of the cheliped, and 3) the morphological similarity with the sounding ridges in certain species of crabs. The inner ridges on the left and right chelipeds are opposed to each other, and the behavior of *N. ryukyuensis* (see Appendix 1: Moving image of live *Nesotanais ryukyuensis*) indicates that the animal can rub the chelipeds. In addition, the structure of these ridges strikingly resembles the stridulatory apparatus reported in two mangrove-dwelling sesarmid crabs, *Perisesarma eumolpe* and *P. indiarum*, used in sound production during agonistic interactions (Boon et al. 2009). Confirmation of actual sound and some hypotheses of function is needed in future studies on these tanaidaceans.

Key to males of the species of *Nesotanais*.

1. Plumose setae of pleopod rami only on distal margin.....***N. maclaughlinae***
– Plumose setae of pleopod rami on distal and outer margins **2**
2. Cheliped dactylus with two strong triangular processes.....***N. lacustris***
– Cheliped dactylus with three small or toothed processes and three spiniform setae..... **3**
3. Maxilliped bases with one pair of ventrodistal setae, shorter than the maxilliped palp; cheliped flange long, with rectangular distal margin.....***N. rugula***
– Maxilliped bases with one pair of ventrodistal setae, longer than maxilliped palp; cheliped flange short, with rounded distal margin ....***Nesotanais ryukyuensis* sp. n.**

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Appendix 1

Moving image of live *Nesotanais ryukyuensis*. doi: 10.3897/zookeys.33.296.app.1.mv.

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